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FREE RECALL OF MINIMAL SERIAL LISTS†[1]

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The present study investigated free recall of subspan (two-noun) lists over a 45-sec. retention interval. The recall lists involved all combinations of high- and low-meaningful nouns. The results showed that free recall of the subspan lists produced many of the effects found with free recall of supraspan lists including a recency effect that diminished with delayed recall. There were also indications that an item's frequency and serial position were complex predictors of probability of recall, interference effects, and recall strategies. The results were discussed in terms of single versus dual processing in memory.

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Both serial position during presentation (cf. Bartz, 1969) and meaningfulness of items (Peterson, Peterson, & Miller, 1961) affect short-term retention of stimulus materials following a *single* input. The theoretical importance of the effect of serial position on recall is found in the suggestion that initial items in a string are stored in long-term memory (LTM), while terminal items in a string are stored in short-term memory (STM) (cf. Bartz, 1969). In the same theoretical vein, the importance of the effect of meaningfulness of STM is that such results provide evidence for continuity of associative processes in STM and LTM (cf. Melton 1963), particularly with respect to proactive mechanisms deriving from prior linguistic experiences.

The present study investigated the joint effects of item position, word frequency (meaningfulness), and proactive inhibition (PI) from prior testing on free recall of nouns over a 45-sec. retention interval. The item position and frequency variables were investigated because of theoretical considerations just discussed. A minimal serial list (two nouns) was used because free recall studies typically involve supraspan lists, and it was of interest to know if findings there would generalize to minimal subspan lists. This comparison is especially important since much of the evidence for continuity of STM and LTM processes comes from serial recall of subspan lists (cf. Melton, 1963), while much of the evidence for dual processing comes from free recall of supraspan lists (cf. Glanzer & Cunitz, 1966). Assuming that findings from prior studies utilizing supraspan lists would generalize to subspan lists, it was anticipated that (*a*) a recency effect would occur but would dissipate with delayed free recall (cf. Glanzer & Cunitz, 1966), (*b*) the initial item would suffer more PI from repeated testing than the terminal item—since according to a two-factor interpretation such items are likely to be in LTM (Bartz, 1969) and, hence, subject to interference effects (cf. Melton, 1963; Turnage, 1970)—and (*c*) that PI effects would be directly related to word frequency, due to correlated opportunities for unit-sequence interference during recall (cf. Turnage, 1967).

METHOD

Materials.—A set of 16 high-frequency (H) nouns and a set of 16 low-frequency (L) nouns of two syllables were used. Within a set, nouns did not call each other out as associates according to norms. The Thorndike-Lorge L-count values were between 1 and 3 for the L words, and between 1014 and 2851 for the H words. The H set was arbitrarily divided into two subsets of 8 words each, and 16 pairs of two items (H-H) were formed by unsystematically pairing each word from the first subset with two different words from the second subset. Then, these H-H pairs were reversed with respect to serial position of items, giving 16 more pairs for a total of 32. Similarly, 32 L-L pairs were formed from the set of L words. Next each of the 16 H words were unsystematically paired with two different words,

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giving a total of 32 H-L pairs. When these pairs were reversed with respect to serial position of items, 32 L-H pairs were obtained. Thus, there were four types of minimal (two nouns) lists: H-H, L-L, H-L, and L-H, with 32 exemplars of each.

Design and procedure.—For each type of pair, the 32 exemplars were arbitrarily divided into eight subsets of four pairs each, with the restriction that a given noun could occur only once within a given subset. Next, retention intervals of 2, 15, 30, and 45 sec. were arranged in terms of a balanced Latin square. Then, the pairs were assigned to be used at each of these retention intervals—two subsets for each list of a given type were assigned to be used with each row of the Latin square—such that the row of the square represented a series of four retention tests involving four different pairs.

Such a counterbalancing procedure permits the *blocking* of *S*s for data analyses so that within each block there appears one *S* whose first recall test was at 2 sec., another *S* whose first recall test was at 15 sec., another whose first was at 30 sec., and another whose first was at 45 sec. Correspondingly, within each block there also appears an *S* whose *second* recall test was at 2 sec., another whose second was at 15 sec., and so on to the fourth recall interval and the last recall test. This blocking procedure was used in the present experiment to analyze PI effects over the 45-sec. interval which might derive from recalling zero to three prior pairs.

The pairs were presented by tape recorder at a 1-sec. rate per item. Each pair was directly followed by a different 3-digit number. The *S*s immediately wrote down this number, counted backwards from it in writing by threes until they heard two bells, then recalled the pairs in any order they wished (free recall instructions). The Ss were instructed to write down a single word if they could not recall both, and 10 sec. were given for recall. The *S*s were closely monitored during their recall task, and their test booklets were examined for indications that they had failed to follow instructions. No *S* was dropped from the experiment for failure to do so.

Subjects.—The 160 *S*s tested were meeting a requirement for an introductory course in psychology at the University of Maryland, and all reported that they spoke English fluently. The *S*s were tested in groups of 5 as they entered the laboratory. Assignment to experimental conditions was on the basis of a predetermined, unsystematic testing order. The 40 *S*s for each type of pair provided 10 blocks for the final data analysis.

RESULTS

All *S*s recalling both items in a pair produced them in their presentation order. An analysis of total intrusions suggested an irregular increase in interference effects over the four tests, with the relevant values being 9, 9, 17, and 13; and over the four retention intervals, with these values being

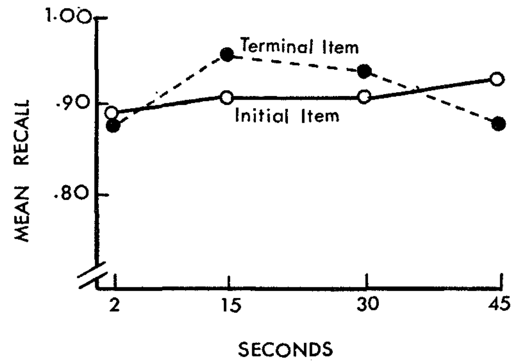

FIG. 1. Mean correct recall per item as a function of item position and time (sec.).

10, 9, 10, and 17, respectively. Misspellings accounted for a large proportion of errors as expected, with the relevant number for H-H, L-H, H-L, and L-L pairs being 2, 28, 38, and 60, respectively. However, these misspellings were not clearly related to either prior testing or time. These total errors were 35, 32, 25, and 36 over the four tests and 37, 29, 45, and 27 over the four retention intervals. Since the category of misspellings is generally not an informative one with auditory presentation, it was consolidated with that of correct recall. Then, *S*s recalling a given type of pair were grouped into blocks (as previously described) for an analysis of variance of the effects of pairs, time, serial position, prior tests, and blocks on recall. The blocks effect served as an estimate of error for between-*S*s effects, while the interaction of blocks with the appropriate repeated-measurement variables served as estimates of error for within-*S*s effects.

Item position.—Although the main effect of item position was not significant at the .05 level, F (1, 36) = .02, the Item Position × Time interaction was, F (3, 108) = 3.75, $p < .05$, and took the form shown in Fig. 1. As can be seen there, a pronounced recency effect obtained at the 15-sec. interval but not at the 45-sec. interval. A similar attenuation of the recency effect has been found with delayed free recall of supraspan lists (Glanzer & Cunitz, 1966), and the present results extend such findings to subspan lists, in the sense that pairs represent minimal lists. The finding that the

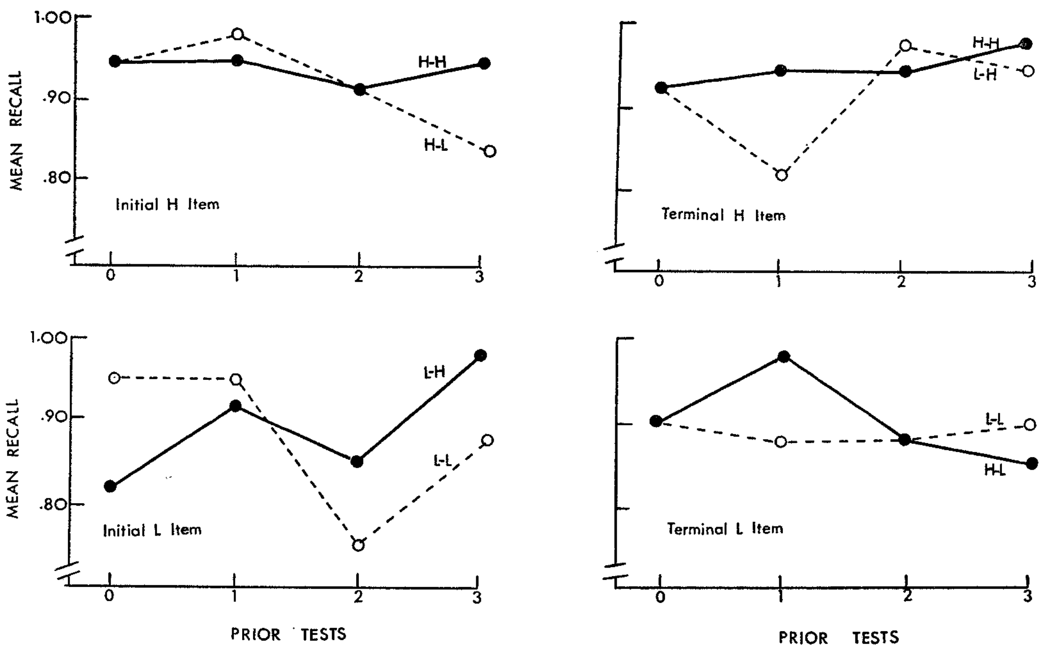

FIG. 2. Mean correct recall per item as a function of pairs (combinations of H and L items), number of prior tests, and item position (initial vs. terminal).

recency effect did not obtain at the 2-sec. test might be related to the fact that supra-span lists necessarily involve greater total presentation time than do pairs, but the precise reasons for such an effect of list length on recall are far from clear. This is especially true since recall level for the initial item remains stable over the 45-sec. interval—suggesting that delay as such did not affect its availability—while variations in recall level for the terminal item are responsible for producing increases and decreases in the recency effect. The suggestions of improvement in recall over time shown by Fig. 1 might be viewed in terms of reminiscence effects which have appeared in paired-associate recall (cf. Keppel & Underwood, 1967). However, there is no particular reason to believe that such effects would be differential with respect to item position in the manner suggested by the present data.

Although the Item Position × Prior Tests interaction fell short of the .05 level of significance, F (3, 108) = 2.60, $p < .10$, its form is worth noting. That is, correct recall slightly increased and then decreased with repeated testing for initial items, but remained relatively stable for terminal items. The relevant means over the four tests, respectively, for initial items were .92, .95, .86, and .92; while for terminal items they were .91, .91, .92 and .92. Similar trends have been shown in serial recall of supraspan lists, including the slight increase in probability of recall for terminal items with repeated testing (Turnage, 1970). In any case, this lower order interaction must be considered in the context of the reliable Item Position × Prior Test × Pairs interaction, F (9, 108) = 2.00, $p < .05$, shown in Fig. 2.

Frequency effects.—The data in Fig. 2 suggest that interference effects for an item of a given frequency, presented in a given position, were greatly dependent on the frequency of the item which preceded or followed it. For example, the initial item in H-H pairs was relatively resistant to interference effects from prior testing, but the initial item in an H-L pair was not. Similarly, the terminal item in L-L pairs was relatively unaffected by repeated testing as compared to the terminal item of an H-L pair. These outcomes, in turn, suggest that the manner in which *S*s encoded the individual items in a pair was complexly related to the position and meaningfulness of both members of the minimal list and to learning-to-learn effects deriving from increased exposure to the testing situation. The same general interpretation also seems reasonable for the reliable Prior Tests × Pair interaction, F (9, 108) = 2.29, $p < .05$, shown in Table 1.

None of the remaining sources of variance reached the .05 level of significance, Fs <.168. Thus, since the Time × Prior Tests interaction was not significant nor was it a component of any higher order interaction, there was no evidence for increased forgetting over time as a function of prior testing in the laboratory.

TABLE 1

MEAN CORRECT RECALL AS A FUNCTION OF PAIRS (COMBINATIONS OF H AND L ITEMS) AND NUMBER OF PRIOR TESTS

Type of pair	Number of prior tests				Column $\bar{X}$
	0	1	2	3	
H-H	.94	.95	.94	.96	.95
H-L	.92	.98	.90	.85	.91
L-H	.88	.88	.91	.96	.91
L-L	.92	.91	.81	.89	.88
Row $\bar{X}$	.92	.93	.89	.92	.92

DISCUSSION

The present results indicate that many of those variables which are important in free recall of supraspan lists are also important in the free recall of subspan lists. As is the case in the "typical" free recall study, it was found in the present study that (*a*) there was a recency effect with immediate recall (cf. Murdock, 1962), (*b*) there was an attenuation of the recency effect with delayed recall (cf. Glanzer & Cunitz, 1966), and (*c*) meaningfulness (frequency) was a complex predictor of recall performance (cf. Deese,1961). However, note in Fig. 1 that the recency effect did not occur at the 2-sec. test and that over the 45-sec. retention interval it increased, then decreased.

As noted previously, differential effects of item position and delayed recall are germane to questions concerning dual storage processes for items in a string. For example, it might be argued that initial items in a string (in LTM?) are most affected by interference effects—from prior inputs in the present situation—and terminal items in a string (in STM?) are most affected by delay. Such an argument follows from theoretical contentions (cf. Melton, 1963) that, in part, failures of LTM may be attributed to associative interference, while failures of STM may be attributed to nonassociative causes such as trace decay over time. In this regard, the present data suggest that recall of the initial item was affected more by interference from prior testing, while recall of the terminal item was affected more by time. Such outcomes are consistent with some form of two-factor theory. However, (*a*) the implication that there is dual-storage processing of *adjacent* items in a minimal list and (*b*) the empirical form the recency effect took over time (see Fig. 1) appear to be complicated propositions to deal with on the basis of a simple two-factor hypothesis. Thus, on one hand, the present data suggest the operation of two distinct storage systems in the encoding of the minimal lists; while on the other hand, they suggest a continuity of processes for STM and LTM with respect to supraspan versus subspan lists and with respect to the influence of meaningfulness.

Proactive mechanisms.—The finding that the frequency of an item affected probability of recall above and beyond pure effects of item position (see Fig. 2) leads to the following consideration. If it is argued from the present data that the initial item in a minimal list was more likely to be stored in LTM, while the terminal item was more likely to be stored in STM, then it must also be argued that proactive mechanisms deriving from the frequency variable operated across both storage stystems. Figure 2 suggests, as does Table 1, a variety of such factors that might be involved such as differential integration of H versus L nouns, coding mechanisms correlated with the frequency dimension (cf. Martin, 1968), learning to learn, and associative interference.

Some of the effects which appeared to vary with frequency of an item have been indicated in prior studies involving both subspan and supraspan lists, and their pertinence has been discussed with respect to continuity between LTM and STM processes (cf. Raser, 1970). For example, free recall level typically increases directly with average list frequency with supraspan lists (Deese, 1961), and the same relationship obtained (averaged across prior tests) in the present study (see Table 1). Whether this trend was due to greater interitem associative strength—in spite of efforts made to control this—or to greater item availability as a function of frequency (cf. Deese, 1961) is difficult to say. Further, although there is some reason to expect that serial recall instructions would lead to poorer retention than was found in the present study, especially for H-H pairs (cf. Turnage, 1967), the fact remains that all *S*s recalling both pair items produced them in the presentation order and that recall level for H-H pairs did not deteriorate over time. This suggests that when serial ordering is not required for minimal lists, *S*s can "naturally" and "easily" produce them in their input order. Of course, it is possible that had an ordering requirement been imposed, no disruption in serial recall would have occurred. However, this seems unlikely in terms of the results generally found as number of recall elements is increased in serial tasks from one to two (cf. Melton, 1963) and in view of theoretical expectations that free recall should continue to improve as a function of frequency, while serial recall should be increasingly disrupted by unit-sequence interference (cf. Turnage & McCullough, 1968). However, recall strategies—which are thought to be operative in STM studies (cf. Turvey & Wittlinger, 1969) and which (logically at least) reflect proactive mechanisms—may turn out to be equally important variables to consider in attempts to disambiguate LTM and STM systems with respect to common mechanisms.

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